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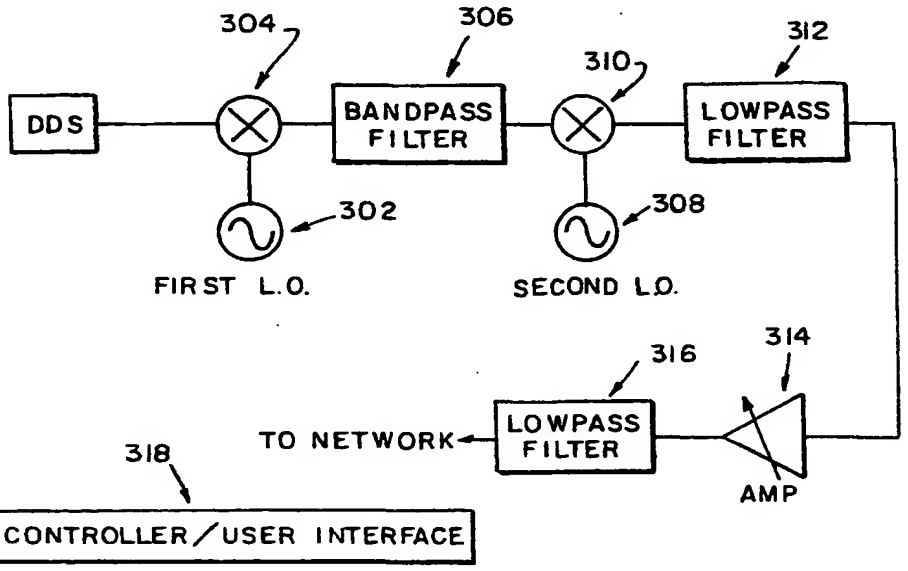

(57) Abstract: An apparatus for testing the phase linearity of a network (CATV system) comprises a first local oscillator (302), a first mixer (304), and a first filter (306), a second local oscillator (308), and a second mixer (310) for mixing the first IF to the desired output frequency. The output of the second mixer (310) is coupled to a second filter (312) which passes the desired frequency band, but rejects the high frequency mixing harmonics produced in the second mixer (310). The output of the second filter (312) is coupled to a variable gain amplifier (314) capable of amplifying the frequency band of interest to the desired level and a third filter (316) which further rejects unwanted high frequencies in the output.

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DETERMINING PHASE LINEARITY IN CATV DISTRIBUTION SYSTEMS

Field of the Invention

This invention relates to methods and apparatus for determining phase linearity in networks. It is disclosed in the context of methods and apparatus for determining the phase linearity of CATV systems, but is believed to have applications to determining the phase linearity of other types of networks as well.

Background of the Invention

Cable television distribution systems typically include a site called a head end where programming material is obtained and modulated onto appropriate carriers. The carriers are then combined for distribution to subscribers over what is typically referred to as the forward path. Signals coming from subscribers in a two way or "interactive" CATV system are typically routed in what is called the return path, and are received and routed to appropriate service providers. CATV signals are distributed and collected on a broadband network. CATV signals typically are transported from head end to subscriber and vice versa as RF or, in hybrid systems including optical transmission portions, RF is converted to light for fiber optic transmission over some portions of the signal path and as RF over other portions of the signal path. This process generally is bi-directional in the case of a hybrid two way CATV system. Depending on the particular architecture of the CATV plant there may exist intermediate signal processing locations.

The distribution for CATV is typically made up of conductors such as coaxial cable and optical fiber with periodic amplifiers to make up for signal loss due to a number of factors including, without limitation, imperfections in the conductors, splitting of the signal during distribution, and so on. In two-way systems, losses of the same general nature occur in the return path.

Of particular importance when transmitting signals in a CATV system is that the signals arrive at useful amplitudes. Among the other important performance criteria for a CATV system is that it not introduce excessive noise or produce distortion in the amplitude and/or phase of the signals. Methods currently exist for measuring these and other defects. For example, signal amplitude has

traditionally been measured with a spectrum analyzer or calibrated tunable receiver called a signal level meter. Noise has sometimes been measured by temporarily removing a carrier and measuring the residual noise in the channel previously occupied by that carrier, or by making a noise measurement at an unoccupied frequency close to a frequency of interest.

Amplitude versus frequency distortion has sometimes been measured by inserting a moving, or swept, test carrier at one end of the system and observing it on (a) receiver(s) at various locations in the system, or by using carriers already on the system, possibly with some added carriers to provide a discrete series of frequency test measurements from which the continuous frequency response of the system can be inferred. Some television signals on CATV systems may also contain imbedded test signals called VITS (Vertical Interval Test Signals) which are added to standard TV signals during the vertical blanking interval. VITS contain bursts of several frequencies within the TV signal's bandwidth, which may be used for approximation of amplitude versus frequency response within the TV signal's occupied bandwidth.

Phase distortion within a TV signal's bandwidth can be measured using a so-called 2T pulse, which is a sine squared pulse located within the vertical interval. By demodulating the TV signal and observing the shape of the 2T pulse at various locations within the system, phase distortion can be approximated although the phase non-linearity versus frequency within the TV signal's bandwidth is not known.

At frequencies at which 2T pulses are not employed, or with non-TV signals, there is no simple method for measuring phase distortion. This application describes a convenient and simple-to-use system for measuring phase distortion in a CATV system.

Disclosure of the Invention

According to one aspect of the invention, apparatus for testing the phase linearity of a network includes a first device for producing test signals spaced at known frequency intervals and with predictable phase relationships and a second device for receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and

determining the phase linearity from the comparison, the first and second devices being adapted for coupling to the network.

Illustratively according to this aspect of the invention, the first device is capable of producing a first test signal having a first center frequency, first lower frequency spectral components, and first higher frequency spectral components, and the second device is capable of determining phase relationships for multiple spectral components of the first test signal.

Illustratively according to this aspect of the invention, the first device is capable of producing a second test signal having a second center frequency, second lower frequency spectral components, and second higher frequency spectral components, and the second device is capable of determining phase relationships for multiple spectral components of the second test signal.

Further illustratively according to this aspect of the invention, the second device is capable of comparing phase relationships among multiple frequency components of the first and second test signals to determine the phase linearity of the network.

Additionally illustratively according to this aspect of the invention, the first device includes a generator for generating at least one of a frequency modulation (FM) signal, an amplitude modulation (AM) signal and a phase modulation (PM) signal, and the second device is capable of tuning across the range of frequencies produced by the generator and processing information from the tuned frequencies.

Illustratively according to this aspect of the invention, the first device further includes a first digital signal processor (DSP).

Further illustratively according to this aspect of the invention, the first device further includes a direct digital synthesizer (DDS).

Additionally illustratively according to this aspect of the invention, the second device is capable of employing a Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison.

Illustratively according to this aspect of the invention, the second device includes a table containing values of the Bessel function for use in evaluating the Bessel function.

Further illustratively according to this aspect of the invention, the first device includes a first local oscillator, a first mixer, and a first filter.

Additionally illustratively according to this aspect of the invention, the second device includes a second mixer for mixing the received test signal, and a second filter coupled to the second mixer.

Illustratively according to this aspect of the invention, the second filter includes a bandpass filter having a center frequency substantially equal to the output of the generator and a sufficiently narrow bandwidth to reject frequencies lower than the lower frequency components and higher than the higher frequency components.

Further illustratively according to this aspect of the invention, the second device further includes a digital signal processor (DSP) capable of fast Fourier transforming (FFTing) a signal related to the output of the second filter to produce a signal related to the determined phase relationship.

Additionally illustratively according to this aspect of the invention, the second device further includes a user interface for displaying an output related to the determined phase relationship.

Illustratively according to this aspect of the invention, at least one of the first and second devices includes a device for producing a signal for synchronizing the transmission by the first device and reception by the second device of the test signals.

Further illustratively according to this aspect of the invention, the first and second devices include information concerning the test frequencies, the synchronizing signals causing the first and second devices to transmit and receive multiple test frequencies in an established sequence.

Additionally illustratively according to this aspect of the invention, the said one of the first and second devices includes a device for transmitting the synchronizing signal on the network.

Illustratively according to this aspect of the invention, at least one of the first and second devices is further adapted for transmitting information related to

the determined phase relationships through the network to at least the other of the first and second devices.

Further illustratively according to this aspect of the invention, the at least one of the first and second devices adapted for transmitting information related to the determined phase relationships through the network is adapted for transmitting the information through a network channel dedicated to the transmission of the information.

Additionally illustratively according to this aspect of the invention, the at least one of the first and second devices adapted for transmitting the information through a network channel dedicated to the transmission of the information includes a device adapted for transmitting the information by frequency shift keying (FSK).

Illustratively according to this aspect of the invention, at least one of the first and second devices is further adapted for producing a signal for synchronizing the transmission by the first device and reception by the second device of the test signals, the information related to the determined phase relationships being transmitted in the same channel as the synchronizing signal.

Further illustratively according to this aspect of the invention, at least one of the first and second devices is further adapted for determining the amplitudes of the received test signals.

Additionally illustratively according to this aspect of the invention, the at least one of the first and second devices adapted for determining the amplitudes of the received test signals is further adapted for comparing the amplitudes of the received test signals to each other to determine variation of the amplitude of the frequency response characteristic across the frequencies contained in the test signals.

Illustratively according to this aspect of the invention, the at least one of the first and second devices adapted for determining the amplitudes of the received test signals is further adapted for comparing the amplitudes of the received test signals to the amplitudes of the transmitted test signals.

Further illustratively according to this aspect of the invention, the other of the at least one of the first and second devices is further adapted for transmitting an indication of the amplitudes of the transmitted test signals.

According to another aspect of the invention, a method for testing the phase linearity of a network, the method including producing on the network test signals spaced at known frequency intervals and with predictable phase relationships, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network.

Illustratively according to this aspect of the invention, producing test signals spaced at known frequency intervals and with predictable phase relationships includes producing a first test signal having a first center frequency, first lower frequency spectral components, and first higher frequency spectral components, and determining the phase relationships of the test signals includes determining phase relationships for multiple spectral components of the first test signal.

Illustratively according to this aspect of the invention, producing test signals spaced at known frequency intervals and with predictable phase relationships includes producing a second test signal having a second center frequency, second lower frequency spectral components, and second higher frequency spectral components, and receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes determining phase relationships for multiple spectral components of the second test signal.

Further illustratively according to this aspect of the invention, determining the phase relationships of the test signals, comparing the determined phase relationships to expected phase relationships among the test signals, and determining from the comparison the phase linearity of the network include comparing the phase relationships among multiple frequency components of the first and second test signals to determine the phase linearity of the network.

Additionally illustratively according to the present invention, producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes generating a test signal, and receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and

determining from the comparison the phase linearity of the network include tuning across the test signal frequency range and processing information from the tuned frequencies.

Illustratively according to this aspect of the invention, producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing with a first digital signal processor (DSP) test signals spaced at known frequency intervals and with predictable phase relationships on the network.

Further illustratively according to this aspect of the invention, producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing with a direct digital synthesizer (DDS) test signals spaced at known frequency intervals and with predictable phase relationships on the network.

Additionally illustratively according to this aspect of the invention, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network include employing a Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison.

Illustratively according to this aspect of the invention, employing a Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison includes employing a table containing values of the Bessel function for use in evaluating the Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison.

Further illustratively according to this aspect of the invention, producing on the network test signals spaced at known frequency intervals and with

predictable phase relationships includes providing a first local oscillator, a first mixer coupled to receive an output of the first local oscillator, and a first filter coupled to receive an output of the first mixer.

Additionally illustratively according to this aspect of the invention, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network include providing a second mixer for mixing the received test signal with an output from a second local oscillator, and a second filter coupled to receive an output from the second mixer.

Illustratively according to this aspect of the invention, providing a second filter includes providing a bandpass filter having a center frequency substantially equal to a center frequency of the test signal and a sufficiently narrow bandwidth to reject frequencies lower than the lower frequency components and higher than the higher frequency components.

Further illustratively according to this aspect of the invention, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network include providing a digital signal processor (DSP) capable of fast Fourier transforming (FFTing) a signal related to the output of the second filter to produce a signal related to the determined phase relationship.

Additionally illustratively according to this aspect of the invention, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network include providing a user interface for displaying an output related to the determined phase relationship.

Illustratively according to this aspect of the invention, the method further includes producing with one of the first and second devices a signal for synchronizing the transmission by the first device and reception by the second device of the test signals.

Further illustratively according to this aspect of the invention, the method includes providing in the first and second devices information concerning the test frequencies to cause the first and second devices to transmit and receive multiple test frequencies in an established sequence.

Additionally illustratively according to this aspect of the invention, the method includes transmitting the synchronizing signal on the network.

Further illustratively according to this aspect of the invention, the method includes transmitting information related to the determined phase relationships through the network from one of the first and second devices to the other of the first and second devices.

Illustratively according to this aspect of the invention, transmitting information related to the determined phase relationships through the network from one of the first and second devices to the other of the first and second devices includes transmitting the information through a network channel dedicated to the transmission of the information.

Additionally illustratively according to this aspect of the invention, transmitting the information through a network channel dedicated to the transmission of the information includes transmitting the information by frequency shift keying (FSK).

Further illustratively according to this aspect of the invention, the method includes producing with one of the first and second devices a signal for synchronizing the transmission by the first device and reception by the second device of the test signals, transmitting information related to the determined phase relationships through the network including transmitting the information related to the determined phase relationships in the same channel as the synchronizing signal.

Further illustratively according to this aspect of the invention, the method includes determining the amplitudes of the received test signals.

Further illustratively according to this aspect of the invention, the method includes comparing the amplitudes of the received test signals to each other to determine variation of the amplitude of the frequency response characteristic across the frequencies contained in the test signals.

Further illustratively according to this aspect of the invention, the method includes comparing the amplitudes of the received test signals to the amplitudes of the transmitted test signals.

Further illustratively according to this aspect of the invention, the method includes transmitting an indication of the amplitudes of the transmitted test signals.

Brief Description of the Drawings

The invention may best be understood by referring to the following detailed description and accompanying drawings which illustrate the invention. In the drawings:

Fig. 1 illustrates an embodiment of a component of a system according to the present invention;

Fig. 2 illustrates an embodiment of another component of a system according to the present invention;

Fig. 3 illustrates another embodiment of a component of a system according to the present invention; and,

Fig. 4 illustrates another embodiment of a component of a system according to the present invention.

Detailed Descriptions of Illustrative Embodiments

A system constructed according to the present invention includes two elements. The first element includes a signal source capable of being modulated in amplitude, frequency, phase, or some combination of amplitude, frequency and phase that produces a signal with spectral elements spaced at known frequency intervals and with predictable phase relationships. The second element includes a receiving device that can receive the just described signal and determine the phase relationships of its various spectral elements. The phase relationships can then be compared to the expected relationships and the phase distortion determined.

By suitable placement of the test signal's spectral elements, several points within its bandwidth can be obtained. The method can be extended to wider bandwidths by setting the test signal to a center frequency so that the lowest

frequency spectral element of the test signal is placed at or near the lowest desired measurement frequency, and noting the phase relationships for each spectral element of the test signal. The test signal can then be moved to a second center frequency such that one or more of the highest spectral elements for the first carrier frequency will be at or near one or more of the lower frequency spectral elements of the second test carrier frequency. Because the phase distortion should be equal for the spectral elements of the first and second test signals which occurred at or near the same frequency, the phase distortion over the combined frequency range can be found. This method may be extended to cover any desired measurement bandwidth by using additional test signal center frequencies as described.

One possible means of implementing the invention is to use a single tone FM generator as the transmitter, and a receiver capable of tuning to the test signal and processing the incoming data. Single tone FM is generated from the following equation:

$$\text{Single Tone FM} = A_c * \cos\{2 * \pi * F_c * t + \beta * \sin(2 * \pi * F_m * t)\}$$

Where: A_c is the amplitude of the test signal;

F_c is the center frequency, or carrier frequency, of the test signal;

β is the modulation index; and,

F_m is the modulation frequency.

Fig. 1 illustrates a transmitter that is capable of producing single tone FM. A digital signal processor (DSP) 101 generates the test signal in digital form and transmits the digital data to a direct digital synthesizer (DDS) 102. The DDS 102 produces a single tone FM signal whose sidebands' amplitudes and phases have predictable relationships with the carrier. The frequency response of a system to single tone FM can be predicted from the Bessel function of the first kind of order n and argument β. The Bessel function cannot be evaluated in closed form. However, many tables can be found that document its properties. See, for example, Ziemer and Tranter, PRINCIPLES OF COMMUNICATIONS, p. 117, which is hereby incorporated herein by reference.

The DDS 102 produces a test signal centered around some intermediate frequency (IF), for example, 20 MHZ. A local oscillator 103 is used to mix the IF signal to a desired output frequency between, for example, 5 MHZ and

1000 MHZ. A bandpass filter 104 filters out the undesired harmonics produced by the mixing process. The RF output 105 is coupled to the channel whose phase distortion characteristics are of interest. The first device can be controlled by a controller, which is typically microprocessor- or microcomputer-based, and can also include additional user interface, such as a keypad, a display, and the like.

A receiver according to the invention is illustrated in Fig. 2. The RF input frequency can vary from, for example, 5 MHZ to 1000 MHZ. A first mixer 201 mixes the input signal to the first IF. This signal is filtered by a bandpass filter 202, which has a bandwidth wide enough to pass the single tone FM information, and narrow enough to reject the unwanted images created by the first mixer 201. A second mixer 203 mixes the input first IF down to a second IF, which frequency an A/D converter 205 is capable of sampling either directly or as an aliased version of itself. A bandpass filter 204 filters the input signal to a bandwidth that is less than the A/D converter's sampling frequency Fs divided by 2 (that is, $< Fs/2$). The A/D converter 205 converts the input signal at the second IF to digital words and passes these digital words to a DSP 206. DSP 206 performs an N point fast Fourier transform (FFT), where N is chosen such that $Fs/N <$ separation of the sidebands in the single tone FM signal. It is also helpful if the single tone FM modulation index (β), modulation frequency (F_m), and center frequency (F_c) are chosen such that the frequencies of interest fall on the centers of the DSP 206's FFT bins. The FFT bin centers appear at multiples of Fs/N between DC and Fs/2. The output from the FFT is in complex form and the phase of each bin is calculated by the equation:

$\tan^{-1}$ (imaginary part of (FFTbin(n))/real part of (FFTbin(n))), where n=0,1,...,N/2-1.

The DSP 206 needs prior knowledge of what FFT bins the single tone FM sidebands of interest reside in. Using this knowledge the DSP 206 can compare the measured phase difference between the single tone FM sidebands of interest and compare the measurements with the ideal phase difference. Any discrepancies will be provided to a user interface 207 as phase distortion. As was the case with the first device, the second device can be controlled by a controller, which is typically microprocessor- or microcomputer-based, and can also include additional user interface, such as a keypad, a display, and the like.

One of the instruments illustrated in Figs. 1 and 2 can control the other. Illustratively the control can be effected through the network itself. In the case of a CATV system, a designated forward or return channel can carry the control signals. In such a situation, control can be initiated by either instrument. For example, the transmitter of Fig. 1 can generate control signals in the forward, or downstream, channel, to synchronize the operation of the transmitter and the receiver of Fig. 2. This can be done using, for example, a table stored in each of the transmitter and receiver, and clocks in both to synchronize their stepping through a sequence of test frequencies. As another alternative, the synchronizing signal can be generated by the receiver illustrated in Fig. 2, indicating that the receiver is ready to initiate the testing protocol.

As another example, the operation of the transmitter illustrated in Fig. 1 and the receiver illustrated in Fig. 2 can be controlled by one or the other of the transmitter and the receiver sending commands through the network indicating to what frequency the other of the transmitter and receiver should next tune to transmit or to receive test signals. In addition, it should be recognized that the functions described for one or the other or both the transmitter and the receiver can be incorporated into instruments which perform one or more additional measurements or other functions, including, but not limited to, signal level measurements, leakage measurements, digital signal measurements and impairments, and so on.

It should further be recognized that when the forward path is being tested for phase linearity, the transmitter illustrated in Fig. 1 will typically be stationary in the headend or at a hub, and the receiver illustrated in Fig. 2 will typically be transported around the network, for example, by a technician. However, when the return path is being tested for linearity, the reverse will typically be the case. That is, the receiver illustrated in Fig. 2 will typically be stationary in the headend or at a hub and the transmitter illustrated in Fig. 1 typically will be transported around the network In at least this latter situation, it will frequently be desirable to transmit either raw data or calculated phase shifts or some other index of the parameter being investigated back to the transmitter. Therefore, it is desirable to incorporate into either one or both of the transmitter and receiver the ability to transmit raw phase shift data, calculated phase shifts or some other index of measured phase shift performance

of the network to the other of the transmitter and receiver. This may be accomplished simply by using the same facility which is used to generate and transmit the synchronizing pulses to transmit the data.

In another example, frequency shift keying can be used to transmit the data. This method is similar to that used for data transmission in, for example, the model 9580 SST and 9580 SSR, both of which are available from Trilithic, Inc., 9202 East 33rd Street, Indianapolis, Indiana 46236. The construction and operation of the 9580 SST and 9580 SSR are hereby incorporated herein by reference. The transmission can take place in any desired location(s) in the forward and/or return path(s). For example, if FSK is used for data transmission, (a) proprietary channel(s) can be set aside for data transmission. Alternatively, one of the existing, otherwise unused forward and/or return channels can be employed for data transmission. It should further be recognized that in a system in which both the transmitter and receiver are equipped with, for example, DSPs and DDSs capable of measuring phase relationships, that it is not necessary to control carefully the transmitted test signal. If the transmitter is capable of determining phase relationships, it can determine the phase relationships of the test signals it is transmitting and transmit this phase information, either as raw data, or as calculated phase shifts, or the like, to the receiver as a separate data packet for use by the receiver in calculating the network's phase shifts. It should also be noted that the amplitude of a channel's frequency response can be determined basically at the same time, simply by knowing or having data transmitted to indicate the amplitude of the transmitted test signal, and the variation of the amplitude of the frequency response can be determined relatively, even without knowing the amplitudes of the transmitted test signals.

In another embodiment of the first device illustrated in Fig. 3, the first device includes a first local oscillator 302, a first mixer 304, and a first filter 306 having a center frequency higher than the highest frequency to transmitted, a second local oscillator 308, and a second mixer 310 for mixing the first IF to the desired output frequency. The output of the second mixer 310 is coupled to a second filter 312 which passes the desired frequency band, but rejects the high frequency mixing harmonics produced in the second mixer 310. The output of the second filter 312 is coupled to a variable gain amplifier 314 capable of amplifying the frequency band of

interest to the desired level and a third filter 316 which further rejects unwanted high frequencies in the output. The first device also includes a user interface 318, which again typically includes a microprocessor- or microcomputer-based controller used to control the operation of device, as well as a keypad, a display, and the like.

Referring now to Figs. 1 and 4, in cases in which the frequency band of interest lies within the capabilities of the DDS 102 illustrated in Fig. 1, the first device may be simplified. Specifically, and with reference to Fig. 4, the first device can include a DDS 102' coupled to a variable gain amplifier 404 capable of amplifying the frequency band of interest to the desired level, and a first filter 104' having a cutoff frequency higher than the highest frequency to be transmitted. Again as with the previous embodiments of both the transmitter and the receiver, the first device can be controlled by a controller 418, which is typically microprocessor- or microcomputer-based, and can also include additional user interface, such as a keypad, a display, and the like.

CLAIMS:

1. Apparatus for testing the phase linearity of a network, the apparatus including a first device for producing test signals spaced at known frequency intervals and with predictable phase relationships and a second device for receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison, the first and second devices being adapted for coupling to the network.

2. The apparatus of claim 1 wherein the first device is capable of producing a first test signal having a first center frequency, first lower frequency spectral components, and first higher frequency spectral components, and the second device is capable of determining phase relationships for multiple spectral components of the first test signal.

3. The apparatus of claim 2 wherein the first device is capable of producing a second test signal having a second center frequency, second lower frequency spectral components, and second higher frequency spectral components, and the second device being capable of determining phase relationships for multiple spectral components of the second test signal.

4. The apparatus of claim 3 wherein the second device is capable of comparing phase relationships among multiple frequency components of the first and second test signals to determine the phase linearity of the network.

5. The apparatus of any preceding claim wherein the first device includes a generator for generating at least one of a frequency modulation (FM) signal, an amplitude modulation (AM) signal and a phase modulation (PM) signal, and the second device is capable of tuning across a range of frequencies produced by the generator and processing information from the tuned frequencies.

6. The apparatus of any preceding claim wherein the first device includes a first digital signal processor (DSP).

7. The apparatus of any preceding claim wherein the first device includes a direct digital synthesizer (DDS).

8. The apparatus of any preceding claim wherein the first device includes a first local oscillator, a first mixer coupled to receive an output of the first mixer, and a first filter coupled to receive an output of the first mixer.

9. The apparatus of any preceding claim wherein the second device includes a second mixer for mixing the received test signal, and a second filter coupled to the second mixer.

10. The apparatus of claim 9 wherein the second device further includes a digital signal processor (DSP) capable of fast Fourier transforming (FFTing) a signal related to the output of the second filter to produce a signal related to the determined phase relationship.

11. The apparatus of claim 9 or 10 wherein the second filter includes a bandpass filter having a center frequency substantially equal to a center frequency of the test signals and a sufficiently narrow bandwidth to reject frequencies lower than lower frequency components of the test signals and higher than higher frequency components of the test signals.

12. The apparatus of any preceding claim wherein the second device is capable of employing a Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison.

13. The apparatus of claim 12 wherein the second device includes a table containing values of the Bessel function for use in evaluating the Bessel function.

14. The apparatus of any preceding claim wherein at least one of the first and second devices includes a device for producing a signal for synchronizing the transmission by the first device and reception by the second device of the test signals.

15. The apparatus of claim 14 wherein the first and second devices include information concerning the test frequencies, the synchronizing signals causing the first and second devices to transmit and receive multiple test frequencies in an established sequence.

16. The apparatus of claim 14 or 15 wherein said one of the first and second devices includes a device for transmitting the synchronizing signal on the network.

17. The apparatus of any preceding claim wherein at least one of the first and second devices is further adapted for transmitting information related to the determined phase relationships through the network to at least the other of the first and second devices.

18. The apparatus of claim 17 wherein the at least one of the first and second devices adapted for transmitting information related to the determined phase relationships through the network is adapted for transmitting the information through a network channel dedicated to the transmission of the information.

19. The apparatus of claim 18 wherein the at least one of the first and second devices adapted for transmitting the information through a network channel dedicated to the transmission of the information includes a device adapted for transmitting the information by frequency shift keying (FSK).

20. The apparatus of claim 17 wherein at least one of the first and second devices is further adapted for producing a signal for synchronizing the transmission by the first device and reception by the second device of the test signals, the information related to the determined phase relationships being transmitted in the same channel as the synchronizing signal.

21. The apparatus of any preceding claim wherein at least one of the first and second devices is further adapted for determining the amplitudes of the received test signals.

22. The apparatus of claim 21 wherein the at least one of the first and second devices adapted for determining the amplitudes of the received test signals is further adapted for comparing the amplitudes of the received test signals to each other to determine variation of the amplitude of the frequency response characteristic across the frequencies contained in the test signals.

23. The apparatus of claim 21 wherein the at least one of the first and second devices adapted for determining the amplitudes of the received test signals is further adapted for comparing the amplitudes of the received test signals to the amplitudes of the transmitted test signals.

24. The apparatus of claim 23 wherein the other of the at least one of the first and second devices is further adapted for transmitting an indication of the amplitudes of the transmitted test signals.

25. The apparatus of any preceding claim wherein the second device further includes a user interface for displaying an output related to the determined phase relationship.

26. A method for testing the phase linearity of a network, the method including producing on the network test signals spaced at known frequency intervals and with predictable phase relationships, receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network.

27. The method of claim 26 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing a first test signal having a first center frequency, first lower frequency spectral components, and first higher frequency spectral components, and receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes determining phase relationships for multiple spectral components of the first test signal.

28. The method of claim 27 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing a second test signal having a second center frequency, second lower frequency spectral components, and second higher frequency spectral components, and receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes determining phase relationships for multiple spectral components of the second test signal.

29. The apparatus of claim 28 wherein the second device is capable of comparing phase relationships among multiple frequency components of the first and second test signals to determine the phase linearity of the network.

30. The method of claim 26, 27, 28 or 29 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes generating at least one of a frequency modulation (FM) signal, an amplitude modulation (AM) signal and a phase modulation (PM) signal, and receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network tuning across a range of frequencies and processing information from the tuned frequencies.

31. The method of any of claims 26 to 30 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing on the network with a first digital signal processor (DSP) test signals spaced at known frequency intervals and with predictable phase relationships.

32. The method of any of claims 26 to 31 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing on the network with a direct digital synthesizer (DDS) test signals spaced at known frequency intervals and with predictable phase relationships.

33. The method of any of claims 26 to 32 wherein producing on the network test signals spaced at known frequency intervals and with predictable phase relationships includes producing on the network using a first local oscillator, a first mixer coupled to receive an output of the first local oscillator, and a first filter coupled to receive an output of the first mixer test signals spaced at known frequency intervals and with predictable phase relationships.

34. The method of any of claims 26 to 33 wherein receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes receiving

the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network using a second mixer for mixing the received test signal, and a second filter coupled to the second mixer.

35. The method of any of claims 26 to 34 wherein receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network using a digital signal processor (DSP) capable of fast Fourier transforming (FFTing) a signal related to the output of the second filter to produce a signal related to the determined phase relationship.

36. The method of any of claims 26 to 35 wherein using a filter includes using a bandpass filter having a center frequency substantially equal to a center frequency of the test signals and a sufficiently narrow bandwidth to reject frequencies lower than lower frequency components of the test signals and higher than higher frequency components of the test signals.

37. The method of any of claims 26 to 36 wherein receiving the signals from the network, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining from the comparison the phase linearity of the network includes employing a Bessel function to perform at least one of receiving the signals, determining their phase relationships, comparing the determined phase relationships to expected phase relationships among the signals, and determining the phase linearity from the comparison.

38. The method of claim 37 wherein employing a Bessel function includes employing a table containing values of the Bessel function for use in evaluating the Bessel function.

39. The method of any of claims 26 to 38 further including producing with one of the first and second devices a signal for synchronizing the transmission by the first device and reception by the second device of the test signals.

40. The method of claim 39 further including providing in the first and second devices information concerning the test frequencies to cause the first and second devices to transmit and receive multiple test frequencies in an established sequence.

41. The method of claim 39 including transmitting the synchronizing signal on the network.

42. The method of any of claims 26 to 41 further including transmitting information related to the determined phase relationships through the network from one of the first and second devices to the other of the first and second devices.

43. The method of claim 42 wherein transmitting information related to the determined phase relationships through the network from one of the first and second devices to the other of the first and second devices includes transmitting the information through a network channel dedicated to the transmission of the information.

44. The method of claim 43 wherein transmitting the information through a network channel dedicated to the transmission of the information includes transmitting the information by frequency shift keying (FSK).

45. The method of claim 42 further including producing with one of the first and second devices a signal for synchronizing the transmission by the first device and reception by the second device of the test signals, transmitting information related to the determined phase relationships through the network including transmitting the information related to the determined phase relationships in the same channel as the synchronizing signal.

46. The method of any of claims 26 to 45 further including determining the amplitudes of the received test signals.

47. The method of claim 46 further including comparing the amplitudes of the received test signals to each other to determine variation of the

amplitude of the frequency response characteristic across the frequencies contained in the test signals.

48. The method of claim 46 further including comparing the amplitudes of the received test signals to the amplitudes of the transmitted test signals.

49. The method of claim 48 further including transmitting an indication of the amplitudes of the transmitted test signals.

50. The method of any of claims 26 to 49 further including displaying an output related to the determined phase relationship.

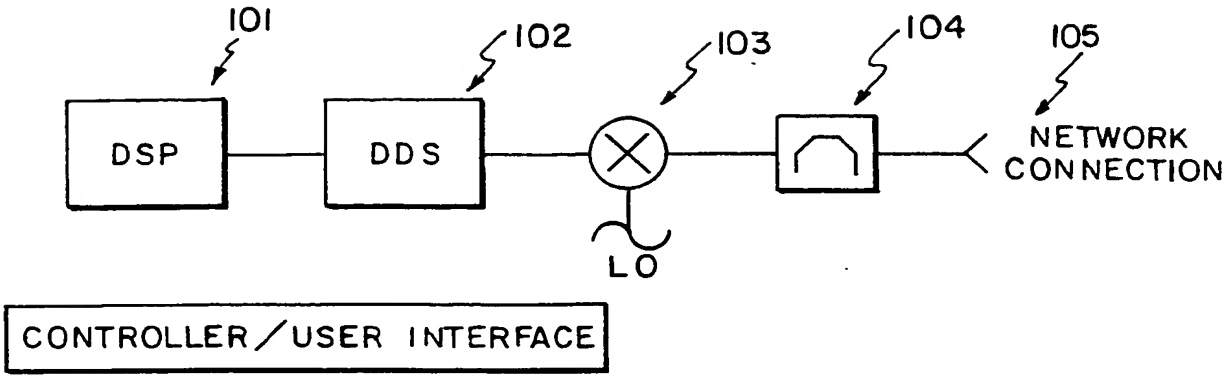
101
102
103
104
105
DSP
DDS
NETWORK CONNECTION
LO
CONTROLLER/USER INTERFACE

FIG. 1

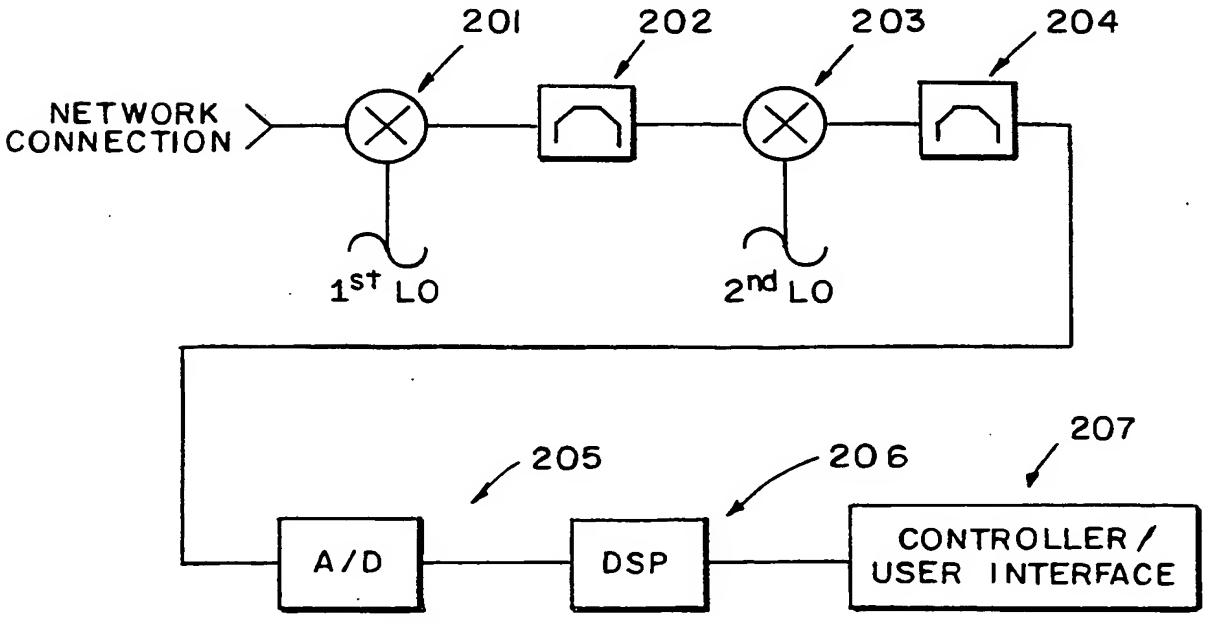
201
202
203
204
NETWORK CONNECTION
1st LO
2nd LO
205
206
207
A/D
DSP
CONTROLLER/ USER INTERFACE

FIG. 2

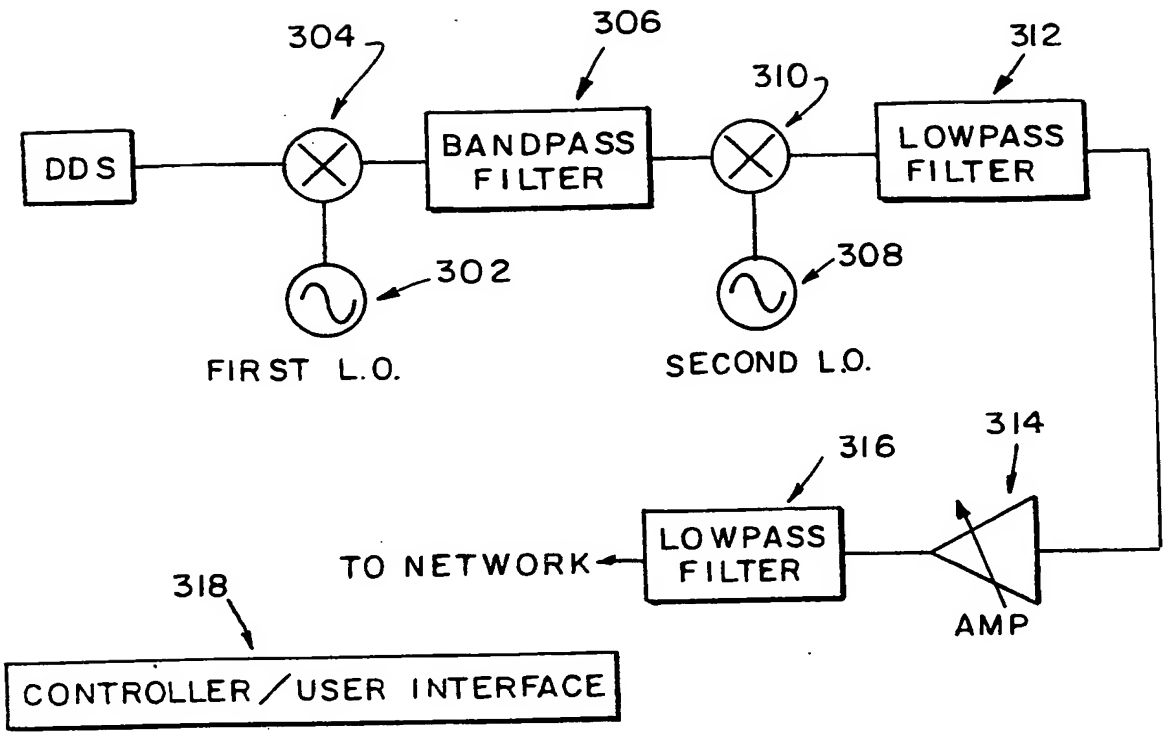
304
306
312
310
DDS
BANDPASS FILTER
LOWPASS FILTER
302
308
FIRST L.O.
SECOND L.O.
314
316
LOWPASS FILTER
TO NETWORK
AMP
318
CONTROLLER/USER INTERFACE

FIG. 3

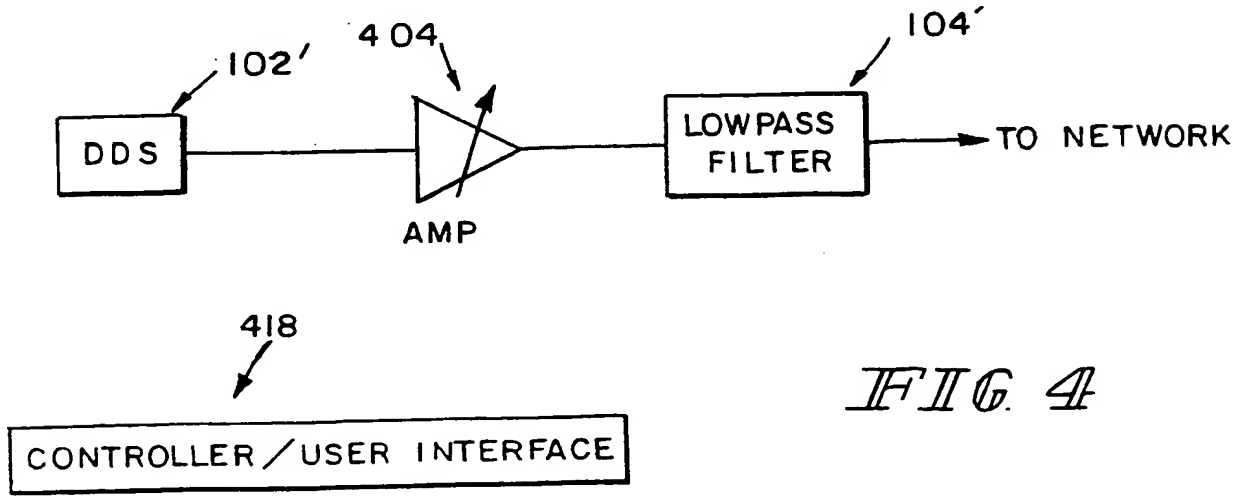
102'
404
104'
DDS
LOWPASS FILTER
TO NETWORK
AMP
418
CONTROLLER/USER INTERFACE

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/25349

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04N 17/00, 17/02
US CL :725/107

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 725/107; 348/12, 13, 180, 192; 455/5.1, 67.6

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5473,361 A (PENNEY) 05 DECEMBER 1995, col. 3, lines 36 to col. 4, lines 17.	1, 26 --- 2-5, 27-30
Y	US 5,270,814 A (MICHEL) 14 DECEMBER 1993, col. 3, lines 49 to col. 10, lines 19.	2-5, 27-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 03 DECEMBER 2000	Date of mailing of the international search report 09 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer NGOC VU Telephone No. (703) 306-5976

Form PCT/ISA/210 (second sheet) (July 1998)★

Express Mail No.: EL230048550US

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: RICHARD D. CONARD
BARNES & THORNBURG
11 SOUTH MERIDIAN STREET
INDIANAPOLLIS, IN 46204

PTO/PCT Rec'd 14 MAR 2002

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 6573 67143	Date of Mailing *(day/month/year)* 09 JAN 2001 **FOR FURTHER ACTION** **See paragraphs 1 and 4 below**
International application No. PCT/US00/25349	International filing date *(day/month/year)* 15 SEPTEMBER 2000
Applicant TRILITHIC, INC.	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer NGOC VU
Facsimile No. (703) 305-3230	Telephone No. (703) 306-5976

Form PCT/ISA/220 (July 1998)★ *(See notes on accompanying sheet)*

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 6573 67143	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US00/25349	International filing date *(day/month/year)* 15 SEPTEMBER 2000	(Earliest) Priority Date *(day/month/year)* 15 SEPTEMBER 1999
Applicant TRILITHIC, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readable form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 3

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/25349

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 6-25
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

International application No.
PCT/US00/25349

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

NEW ABSTRACT

An apparatus for testing the phase linearity of a network (CATV system) comprises a first local oscillator (302), a first mixer (304), and a first filter (306), a second local oscillator (308), and a second mixer (310) for mixing the first IF to the desired output frequency. The output of the second mixer (310) is coupled to a second filter (312) which passes the desired frequency band, but rejects the high frequency mixing harmonics produced in the second mixer (310). The output of the second filter (312) is coupled to a variable gain amplifier (314) capable of amplifying the frequency band of interest to the desired level and a third filter (316) which further rejects unwanted high frequencies in the output.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:
RICHARD D. CONARD
BARNES & THORNBURG
11 SOUTH MERIDIAN STREET
INDIANAPOLIS, IN 46204

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	08 APR 2002
Applicant's or agent's file reference 6573 67143	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US00/25349	15 September 2000 (15.09.2000)	15 September 1999 (15.09.1999)

Applicant

TRILITHIC, INC.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Andrew Faile Telephone No. 703-306-0377

Form PCT/IPEA/416 (July 1992)

10/088,127

5

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 6573 67143	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/25349	International filing date *(day/month/year)* 15 September 2000 (15.09.2000)	Priority date *(day/month/year)* 15 September 1999 (15.09.1999)
International Patent Classification (IPC) or national classification and IPC IPC(7): H04N 7/173 and US Cl.: 725/107		
Applicant TRILITHIC, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of report with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
23 March 2001 (23.03.2001)	March 25, 2002
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Andrew Faile Telephone No. 703-306-0377

Form PCT/IPEA/409 (cover sheet)(July 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/25349

I. Basis of the report

1. With regard to the elements of the international application:*

☒ the international application as originally filed.

☒ the description:
pages 1-15 as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

☒ the claims:
pages 16-23, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

☒ the drawings:
pages 1-2, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

☐ the sequence listing part of the description:
pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/25349

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The question whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been and will not be examined in respect of:

☐ the entire international application,

☒ claims Nos. 6-25 and 31-50

because:

☐ the said international application, or the said claim Nos. ____ relate to the following subject matter which does not require international preliminary examination *(specify)*:

☒ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. 6-25 and 31-50 are so unclear that no meaningful opinion could be formed *(specify)*:

Those claims are not examined because they included improper multiple dependent claims such as "any preceding claims" or "any of claims".

☐ the claims, or said claims Nos. ____ are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for said claims Nos. ____

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/25349

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	1-5 AND 26-30	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-5 AND 26-30	NO
Industrial Applicability (IA)	Claims	1-5 AND 26-30	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

Claims 1 and 26 lack novelty under PCT Article 33(2) as being anticipated by Penney (US 5,473,361).

Regarding claims 1 and 26, Penny discloses an apparatus and method for test and measurement parameters of a network, comprising a first device (source 12) for producing test signals spaced at known frequency intervals and with predictable phase relationships (a sample of the broadband video signal output from the headend), and a second device (40) for receiving the signals; determining their phase relationships (measurement of the demodulated video such as differential phase and gain, comparing the determined phase relationships to expected phase relationships among the signals; and determining the phase linearity from the comparison (measuring the parameters of the broadband video at a point in the distribution system, and displaying the differences between the parameters as measured at the headend and at the point in the distribution system); wherein the first and second devices being adapted for coupling to the network (see figure; col. 3-4, lines 35-32).

Claims 2-5 and 27-30 lack an inventive step under PCT Article 33(3) as being obvious over Penney (US 5,473,361) in view of Michel (US 5,270,814).

Regarding claims 2-5 and 27-30, Penney discloses the apparatus and method including the first device and second device for producing the test signals, but Penney does not specifically disclose means for generating a frequency modulation signals, an amplitude modulation signals and a phase modulation signals. However, Michel discloses a method and apparatus for measuring the linearity of a transmission system by detecting the strength of an inter-carrier frequency included amplitude modulation of the sound signal and modulates the image signal (abstract, col. 4-10, lines 11-40). The useful component in this measurement is the modulating component for movement which displaces the image signal ahead of the characteristic. It is therefore advisable to promote it in order to reveal the linearity defects.

Claims 1-5 and 26-30 meet the criteria set out in PCT Article 33(4) and thus have industrial applicability, because apparatus and method for testing the phase liearity can be made and/or used in CATV network.

----------NEW CITATIONS----------
NONE

Express Mail No.: EL230048550US

PTO/PCT Rec'd 14 MAR 20

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 6573 67143

Box No. I TITLE OF INVENTION

DETERMINING PHASE LINEARITY IN CATV DISTRIBUTION SYSTEMS

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

TRILITHIC, INC.
9202 East 33rd Street
Indianapolis, IN 46236
US

☐ This person is also inventor.

Telephone No.
(317) 895-3600

Facsimile No.
(317) 895 3613

Teleprinter No.

State *(that is, country)* of nationality:
US

State *(that is, country)* of residence:
US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

EMSLEY, Brett W.
2914 Sunmeadow Court
Indianapolis, IN 46228
US

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:
US

State *(that is, country)* of residence:
US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

CONARD, Richard D.
BARNES & THORNBURG
11 South Meridian Street
Indianapolis, IN 46204
US

Telephone No.
(317) 236-1313

Facsimile No.
(317) 231-7344

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. . . . 2 . .

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

RODGERS, Gregg Stephen
208 Yorkshire Circle
Noblesville, IN 46060
US

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [XX] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

[ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

☐ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☐ **AE** United Arab Emirates
☐ **AG** Antigua and Barbuda
☐ **AL** Albania .....
☐ **AM** Armenia .....
☐ **AT** Austria .....
☒ **AU** Australia .....
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina .....
☐ **BB** Barbados
☐ **BG** Bulgaria .....
☒ **BR** Brazil .....
☐ **BY** Belarus .....
☐ **BZ** Belize
☒ **CA** Canada
☐ **CH and LI** Switzerland and Liechtenstein
☒ **CN** China .....
☐ **CR** Costa Rica .....
☐ **CU** Cuba .....
☐ **CZ** Czech Republic .....
☐ **DE** Germany .....
☐ **DK** Denmark .....
☐ **DM** Dominica
☐ **DZ** Algeria .....
☐ **EE** Estonia .....
☐ **ES** Spain .....
☐ **FI** Finland .....
☐ **GB** United Kingdom
☐ **GD** Grenada
☐ **GE** Georgia .....
☐ **GH** Ghana .....
☐ **GM** Gambia
☐ **HR** Croatia .....
☐ **HU** Hungary .....
☐ **ID** Indonesia
☐ **IL** Israel .....
☐ **IN** India .....
☐ **IS** Iceland
☒ **JP** Japan .....
☐ **KE** Kenya .....
☐ **KG** Kyrgyzstan .....
☐ **KP** Democratic People's Republic of Korea .....
☐ **KR** Republic of Korea .....
☐ **KZ** Kazakhstan .....
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho .....
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MA** Morocco .....
☐ **MD** Republic of Moldova .....
☐ **MG** Madagascar .....
☐ **MK** The former Yugoslav Republic of Macedonia .....
☐ **MN** Mongolia
☐ **MW** Malawi .....
☐ **MX** Mexico .....
☐ **MZ** Mozambique
☐ **NO** Norway
☐ **NZ** New Zealand .....
☐ **PL** Poland .....
☐ **PT** Portugal .....
☐ **RO** Romania
☐ **RU** Russian Federation .....
☐ **SD** Sudan
☐ **SE** Sweden
☐ **SG** Singapore
☐ **SI** Slovenia .....
☐ **SK** Slovakia .....
☐ **SL** Sierra Leone .....
☐ **TJ** Tajikistan .....
☐ **TM** Turkmenistan .....
☐ **TR** Turkey .....
☐ **TT** Trinidad and Tobago .....
☐ **TZ** United Republic of Tanzania
☐ **UA** Ukraine .....
☐ **UG** Uganda .....
☒ **US** United States of America .....
☐ **UZ** Uzbekistan .....
☐ **VN** Viet Nam .....
☐ **YU** Yugoslavia .....
☐ **ZA** South Africa .....
☐ **ZW** Zimbabwe .....

Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

See Notes to the request form

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) (15.09.99) 15 September 1999	60/154,131	US		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA / US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:	4
description (excluding sequence listing part)	:	15
claims	:	8
abstract	:	1
drawings	:	2
sequence listing part of description	:	0
Total number of sheets	:	30

This international application is **accompanied by** the item(s) marked below:

1. ☒ fee calculation sheet
2. ☒ separate signed power of attorney
3. ☒ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: Transmittal Letter to the US/RO Return Postal Card

Figure of the drawings which should accompany the abstract: 3

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Richard D. Conard, Agent for Applicant

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s):
(Family name followed by given name; for a full legal entity, full official designation. The address must include postal code and name of country.)

TRILITHIC, INC.
9202 E. 33rd Street
Indianapolis, IN 46236
US

hereby appoint(s) the following person as: ☒ agent ☐ common representative

Name and address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

CONARD, Richard D.; LAMMERT, Steven R.;NIEDNAGEL, Timothy E.; COFFEY, William R.; REZEK, Richard A.; WAITE, Kenneth J.; HARRISON, Nancy J.; CARTER, R. Trevor; KULKARNI, Dilip A.; QUICK, David B.; POWLICK, Jill T.; HEDGES, Norman J.; PALAN, Perry; NEWMAN, Mark M.; GILLENWATER, Bobby B.; HUNT, Paul B.; GZYBOWSKI, Michael S.; GALLAGHER, Gerard T.; NULL, Robert D.; MARTIN, Alice O.; and COOPER, Gregory S.
all of the law firm: BARNES & THORNBURG
11 South Meridian Street
Indianapolis, IN 46204
US

to represent the undersigned before

☒ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

US as receiving Office

and to make or receive payments on behalf of the undersigned.

Signature(s) *(where there are several persons, each of them must sign; next to each signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):*

Terry BUSH, Vice President

Date: 11/16/99 16 November 1999 (16.11.99)

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s) :
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

EMSLEY, Brett W.
2914 Sunmeadow Court
Indianapolis, IN 46228
US

hereby appoint(s) the following person as: [XX] agent [ ] common representative

Name and address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

CONARD, Richard D.; COFFEY, William R.; LAMMERT, Steven R.; REZEK, Richard A.; HARRISON, Nancy, J.; KULKARNI, Dilip A.; QUICK, David B.; POWLICK, Jill T.; STEIN, Arland T.; RICHARDS, William B.; HAIGH, Christopher E.; SWEENEY, James R. II; BALL, Rebecca L.; PALAN, Perry; NEWMAN, Mark M.; GILLENWATER, Bobby B.; HUNT, Paul B.; MARTIN, Alice O.; COOPER, Gregory S.;
All Appointed Agents of the Address:
BARNES & THORNBURG
11 South Meridian Street
Indianapolis, IN 46204
US

to represent the undersigned before

[XX] all the competent International Authorities
[ ] the International Searching Authority only
[ ] the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

US as receiving Office

and to make or receive payments on behalf of the undersigned.

Signature(s) *(where there are several persons, each of them must sign; next to each signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power)*:

Brett W Emsley
Brett W. EMSLEY

(21.09.00)
Date: 9 / 21 / 00
Day/ Month/ Year

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s):
(Family name followed by given name; for a full legal entity, full official designation. The address must include postal code and name of country.)

RODGERS, Gregg Stephen
208 Yorkshire Circle
Noblesville, IN 46060
US

hereby appoint(s) the following person as: ☒ agent ☐ common representative

Name and address
(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

CONARD, Richard D.; LAMMERT, Steven R.;NIEDNAGEL, Timothy E.; COFFEY, William R.; REZEK, Richard A.; WAITE, Kenneth J.; HARRISON, Nancy J.; CARTER, R. Trevor; KULKARNI, Dilip A.; QUICK, David B.; POWLICK, Jill T.; HEDGES, Norman J.; PALAN, Perry; NEWMAN, Mark M.; GILLENWATER, Bobby B.; HUNT, Paul B.; GZYBOWSKI, Michael S.; GALLAGHER, Gerard T.; NULL, Robert D.; MARTIN, Alice O.; and COOPER, Gregory S.
all of the law firm: BARNES & THORNBURG
11 South Meridian Street
Indianapolis, IN 46204
US

to represent the undersigned before

☒ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

US as receiving Office

and to make or receive payments on behalf of the undersigned.

Signature(s) *(where there are several persons, each of them must sign; next to each signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):*

Gregg S. Rodgers

Gregg S. RODGERS
Gregg Stephen RODGERS

Date: 11/16/99 16 November 1999 (16.11.99)